TG10 Status Report

- New development of MaGe
- MC campaign II of Gerda
- Simulation of tolerable contaminations
- Pulse shape simulation

Jing Liu @ GERDA Collab. Meeting, Cracow

New development of MaGe

- New source confinement macros
- New output schema
- New geometry overlapping checking tool
- New version of Geant4
- MaGe paper

New source confinement macros

Confinement in geometrical volumes or surfaces

It is also possible ... position of the primary event uniformly in a geometrical volume (e.g. a spherical ... re). Although this functionality ... ee sect. 6.10), the General Particle Source ... ble to use the tools described in Sect. 6.12, as the sampling of the direction of the primary particle within a given angle from a target position. The position sampling over a geometrical volume/surface, as provided by MaGe , can be coupled with the tools for direction sampling.

MaGe - the GERDA/Majorana Monte Carlo framework

A user's and developer's guide for GERDA members

An application for example:

estimate the background due to γ-rays from the bottom of the water tank

New source confinement macros

The confinement level is set with the command

```
/MG/generator/confine   [noconfined] [geometricalvolume] [geometricalsurface]
```

The shape for the geometrical volume/surface can be set with the commands

```
/MG/generator/geomSampling/volume/name [Sphere] [Cylinder]
/MG/generator/geomSampling/surface/name [Sphere] [Cylinder] [Disk]
```

Shape

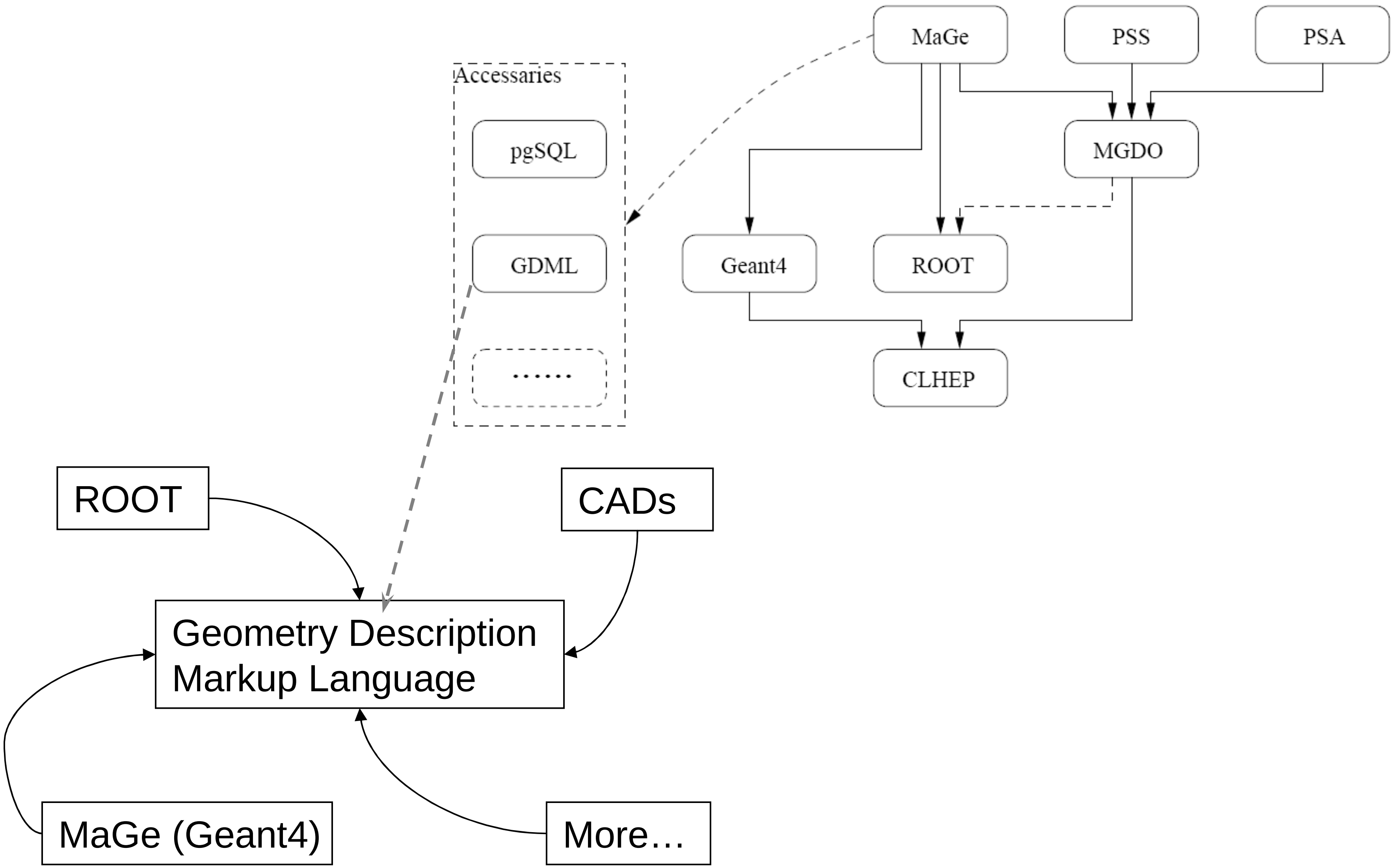
```
/MG/generator/geomSampling/volume/center x y z [cm]
/MG/generator/geomSampling/surface/center x y z [cm]
```

Position

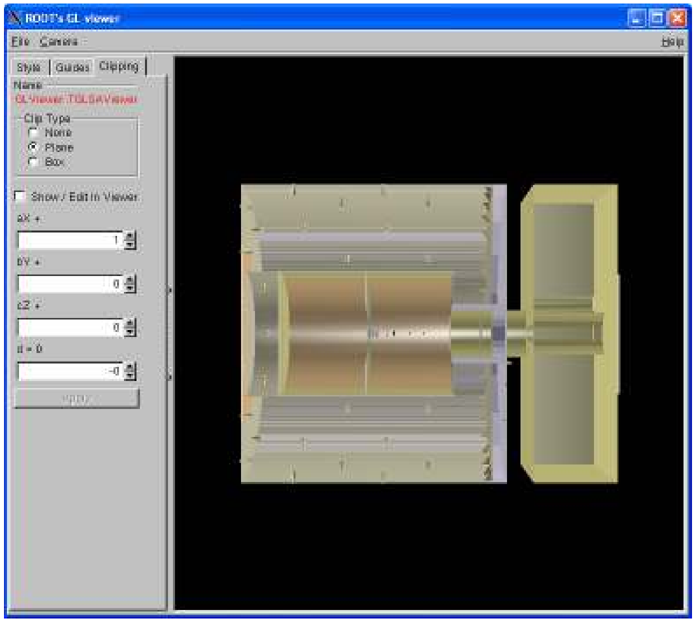
```
/MG/generator/geomSampling/volume/innerSphereRadius x [cm]
/MG/generator/geomSampling/volume/outerSphereRadius x [cm]

/MG/generator/geomSampling/surface/sphereRadius x [cm]

/MG/generator/geomSampling/surface/innerDiskRadius x [cm]
/MG/generator/geomSampling/surface/outerDiskRadius x [cm]

/MG/generator/geomSampling/surface/innerCylinderRadius x [cm]
/MG/generator/geomSampling/surface/outerCylinderRadius x [cm]
/MG/generator/geomSampling/surface/cylinderHeight x [cm]

/MG/generator/geomSampling/volume/innerCylinderRadius x [cm]
/MG/generator/geomSampling/volume/outerCylinderRadius x [cm]
/MG/generator/geomSampling/volume/cylinderHeight x [cm]
```

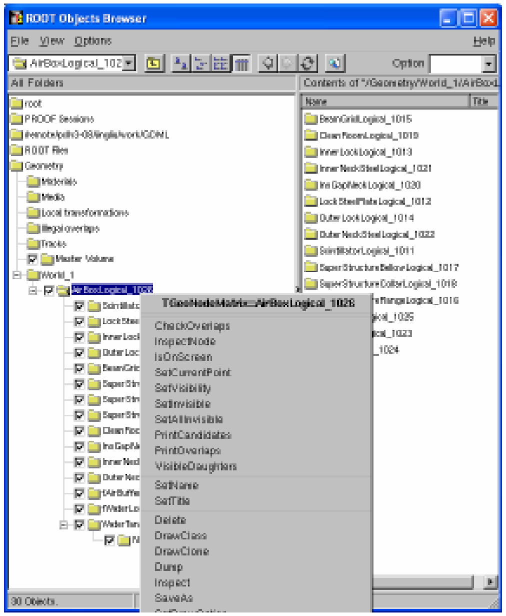
Dimension

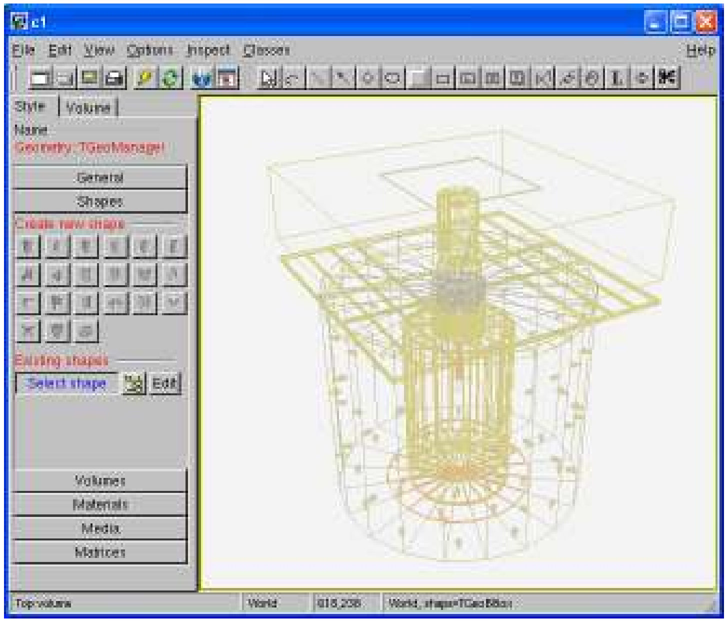
GDML is enabled for MaGe as an accessary



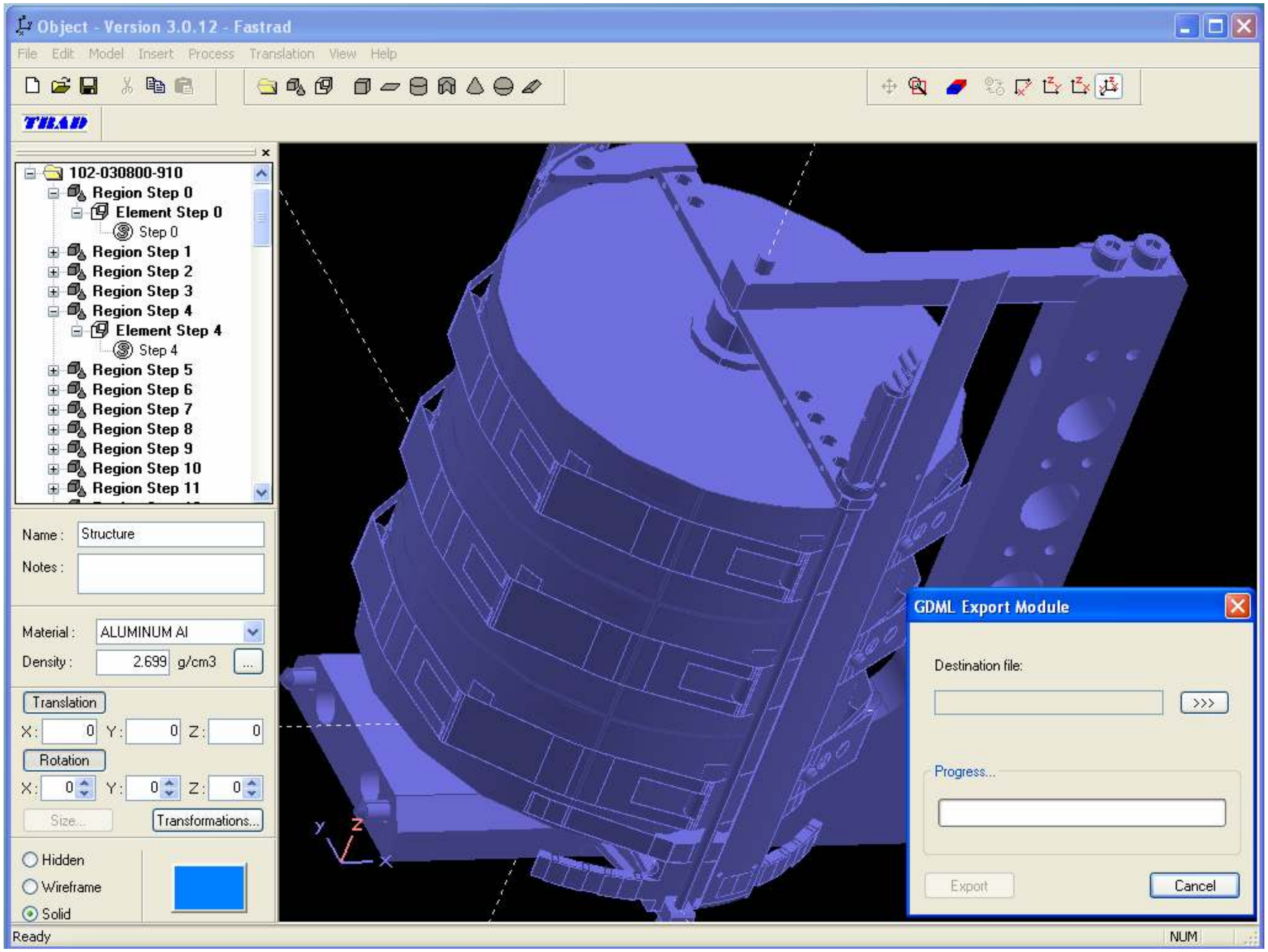
GDML goes with MaGe and ROOT







CAD to GDML


Object - Version 3.0.12 - Fastrad
File Edit Model Insert Process Translation View Help
102-030800-910
Region Step 0
Element Step 0
Step 0
Region Step 1
Region Step 2
Region Step 3
Region Step 4
Element Step 4
Step 4
Region Step 5
Region Step 6
Region Step 7
Region Step 8
Region Step 9
Region Step 10
Region Step 11
Name : Structure
Notes :
Material : ALUMINUM Al
Density : 2.699 g/cm3
Translation
Rotation
Size...
Transformations...
Hidden
Wireframe
Solid
Ready
NUM
GDML Export Module
Destination file:
>>>
Progress...
Export
Cancel

New output class for GDML implemented in MaGe

Not easy to assign “sensitive detector” to volumes defined in GDML so that the hits in those volumes can be recorded.

MaGe Users Manual

A new way to declare volumes as “sensitive detectors” is applied in this new output class:

Include string “sensitive” in the physical volume name (very easy, useful to check complex geometry by simulation)

Output of this new class

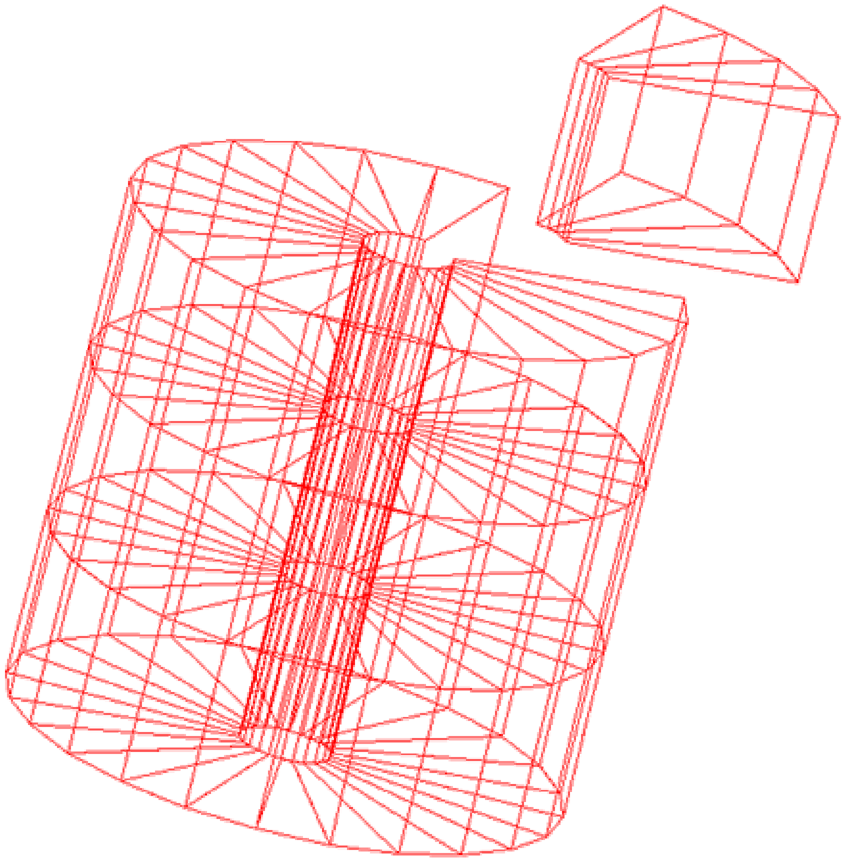
- source info
  - total number
  - position
  - time (=0)
  - four momentum
  - particle type

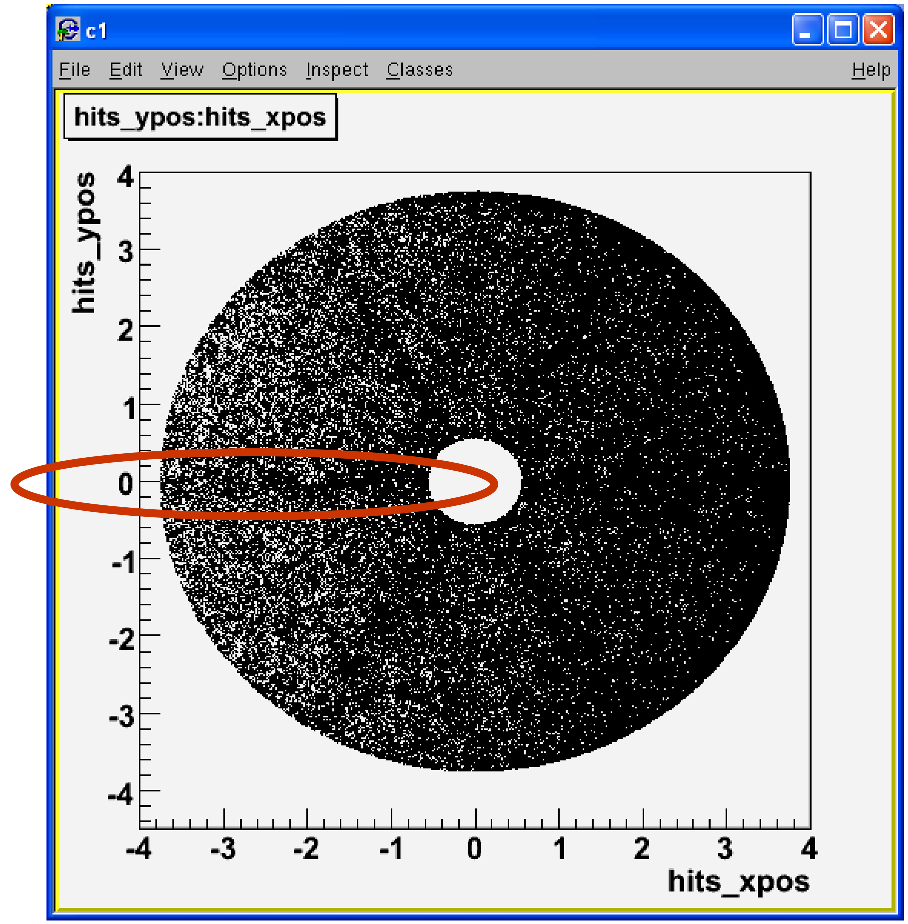
```
/MG/eventaction/Crystal/save [source, hits, tracks, all]
```

- source - saves only the primary vertex and particles information
- hits - saves the hits and trajectories in the sensitive volumes
- tracks - saves all hits and all trajectories
- all - saves, well, all..

- hits info
  - total number
  - global position
  - local position
  - time
  - energy deposition
  - particle type
  - tracking info
  - crystal info
    - crystal type
    - crystal ID
    - segment ID
    - seg. energy [cr.ID] [seg.ID]

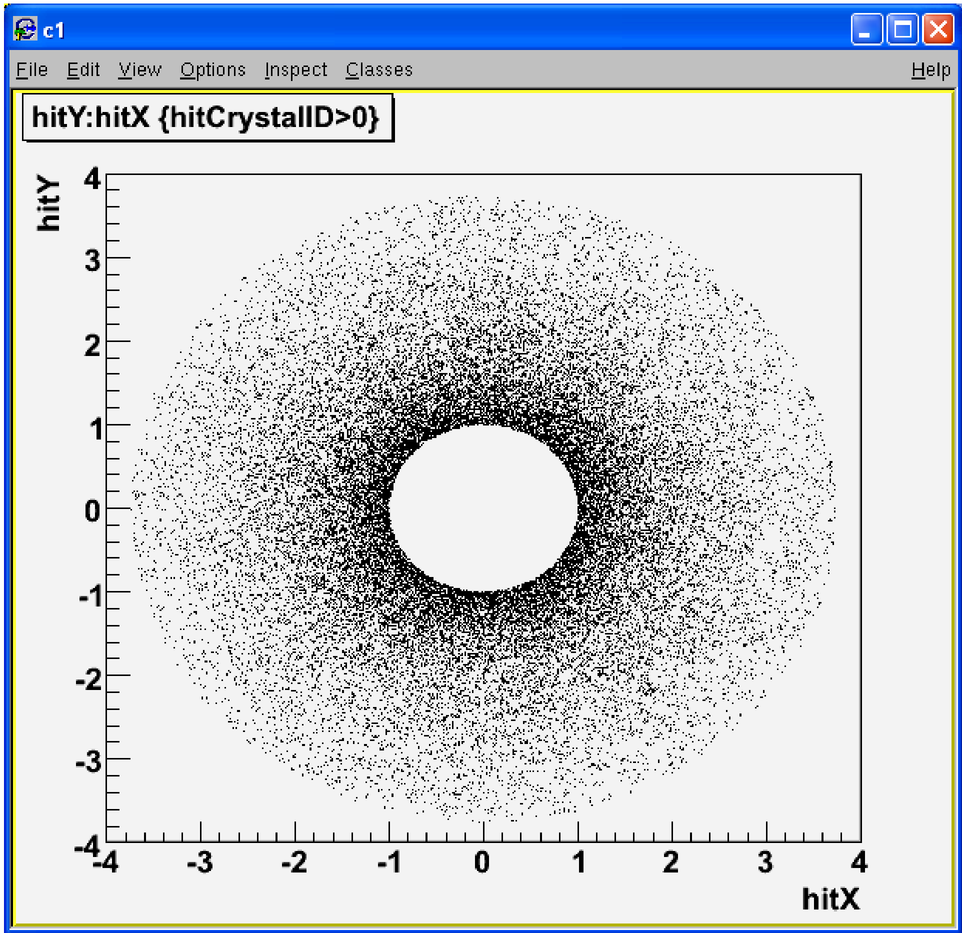
Old segmentation method

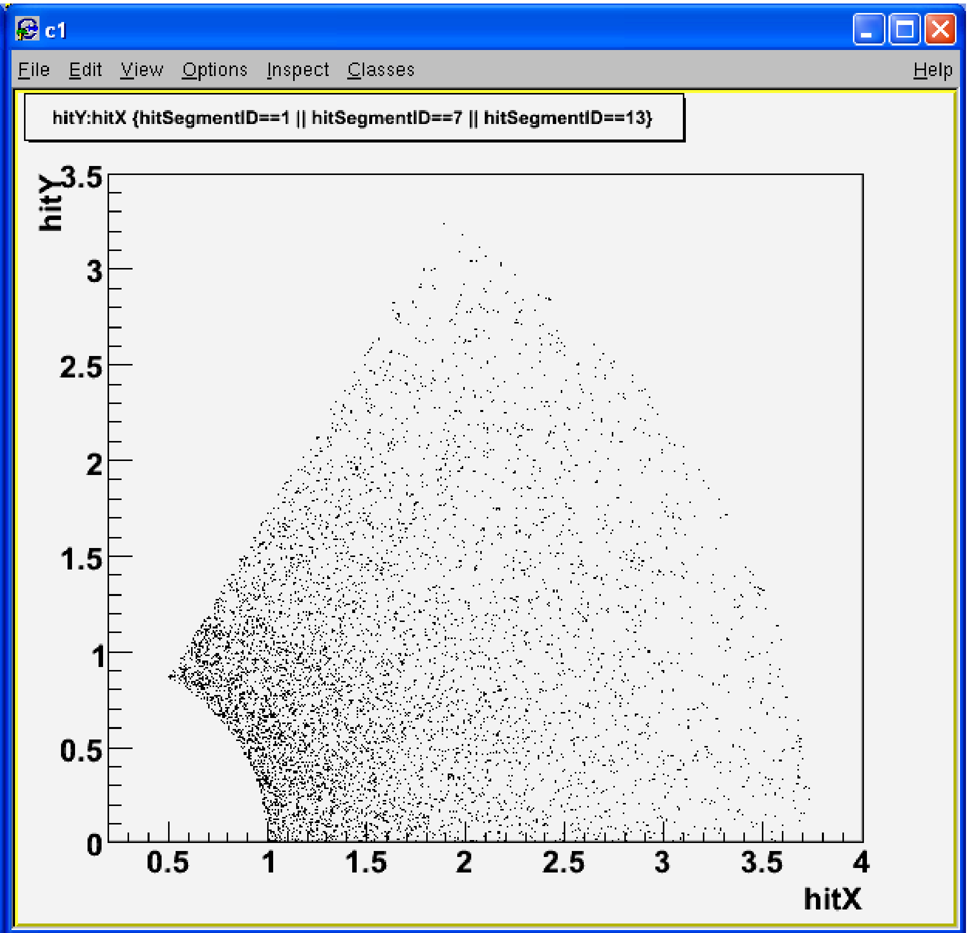




New segmentation method

Crystal is modeled in MaGe as a single cylinder;
Hits are assigned to different segments according to their local positions.





New geometry overlapping checking tool

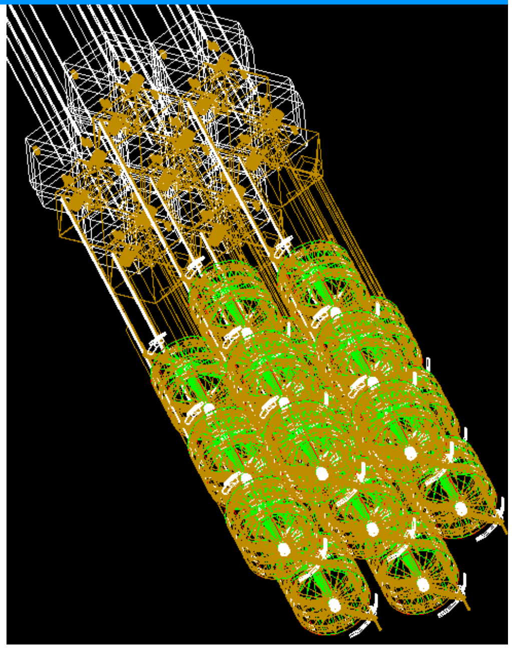
A command is available to check for overlapping volumes within the geometry.

```
Idle> /MG/geometry/CheckOverlaps
```

The program will report on the screen the overlaps between physical volumes with their mother volume and/or with other physical volumes at the same hierarchy level. No information is displayed for those volumes that are correctly placed. Additional verbosity from the CheckOverlaps tool, can be obtained with the command

```
Idle> /MG/geometry/OverlapVerbosity true/false
```

(default is false).



A test on old Gerda geometry

```
WARNING - G4PVPlacement::CheckOverlaps()
          Overlap is detected for volume Cable_15
          with Cable_16 volume's
          local point (35.6626,-12.2796,81.2548), overlapping by at lea
st: 8.44902 um
```

Geant4 bugs

Gerda Scientific/Technical Report GSTR-07-010 v2

Study of the γ-ray branching ratios of nuclear decays in Geant4

D. Budjas[a], *L. Pandola*[b]

[a] Max-Planck Institute for Nuclear Physics, Heidelberg, Germany
[b] INFN, Gran Sasso National Laboratory, Assergi, Italy

Wrong branching ratios of several gamma lines in Geant4.8.x reported to Geant4 bug tracking system:
Bug: #952, #968, #970

Study of Neutron Interactions with A Segmented Germanium Detector

I. Abt, A. Caldwell, K. Kröninger, J. Liu *, X. Liu, B. Majorovits

Max-Planck-Institut für Physik, München, Germany

Meta-stable states missing
Bug: #956

Bugs of wrong branching ratios fixed in Geant4.9.1

Details

Summary: Change of branching ratios for radioactive decays

Problem#:	952	**Hardware**:	All
Product:	Geant4	**OS**:	All
Component:	processes/hadronic/models/radioactive_decay	**Version**:	8.2
Status:	RESOLVED	**Priority**:	P3
Resolution:	FIXED	**Severity**:	normal

Details

Summary: Wrong G4ContinuumGammaDeexcitation::CanDoTransition() for...

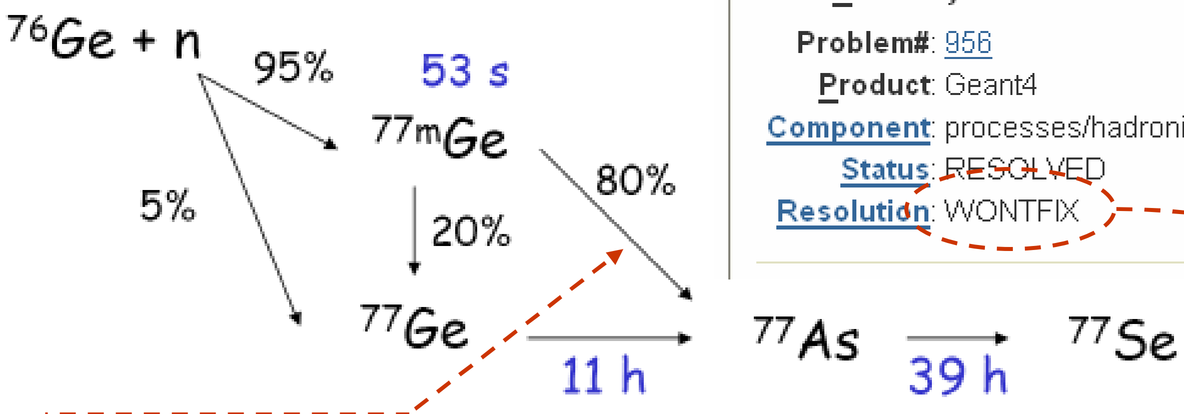
Problem#:	968	**Hardware**:	All
Product:	Geant4	**OS**:	All
Component:	processes/hadronic/models/de_excitation/photon_evaporation	**Version**:	other
Status:	RESOLVED	**Priority**:	P3
Resolution:	FIXED	**Severity**:	trivial

Details

Summary: Branching ratio of weak gamma lines artificially set to 1e-5

Problem#:	970	**Hardware**:	All
Product:	Geant4	**OS**:	All
Component:	processes/hadronic/models/de_excitation/photon_evaporation	**Version**:	other
Status:	RESOLVED	**Priority**:	P5
Resolution:	FIXED	**Severity**:	trivial

Bug of meta stable states unfixed



$Q_\beta = 2.8$ MeV

Details

Summary: meta stable states are missing

Problem#: 956
Product: Geant4
Component: processes/hadronic/models/neutron_hp
Status: ~~RESOLVED~~
Resolution: WONTFIX

Hardware: All
OS: All
Version: 8.3
Priority: P5
Severity: normal

```
We have looked into this problem and found that Geant4 does not support
meta-stable states.  The photon evaporation code is used instead for a very
rough approximation, but it will not generate the lines you want.

To add this capability would be a large job which we cannot undertake at this
time.
```

MaGe paper submitted

arXiv.org > nucl-ex > arXiv:0802.0860

Search (Help | Advanced search)

Nuclear Experiment

MaGe - a Geant4-based Monte Carlo framework for low-background experiments

Yuen-Dat Chan, Jason A. Detwiler, Reyco Henning, Victor M. Gehman, Rob A. Johnson, David V. Jordan, Kareem Kazkaz, Markus Knapp, Kevin Kroninger, Daniel Lenz, Jing Liu, Xiang Liu, Michael G. Marino, Akbar Mokhtarani, Luciano Pandola, Alexis G. Schubert, Claudia Tomei

(Submitted on 6 Feb 2008)

A Monte Carlo framework, MaGe, has been developed based on the Geant4 simulation toolkit. Its purpose is to simulate physics processes in low-energy and low-background radiation detectors, specifically for the Majorana and Gerda ^{76}Ge neutrinoless double-beta decay experiments. This jointly-developed tool is also used to verify the simulation of physics processes relevant to other low-background experiments in Geant4. The MaGe framework contains simulations of prototype experiments and test stands, and is easily extended to incorporate new geometries and configurations while still using the same verified physics processes, tunings, and code framework. This reduces duplication of efforts and improves the robustness of and confidence in the simulation output.

Draft went through
GERDA & Majorana EB
Submitted to
IEEE Trans. Nucl. Scie.

References & Citations

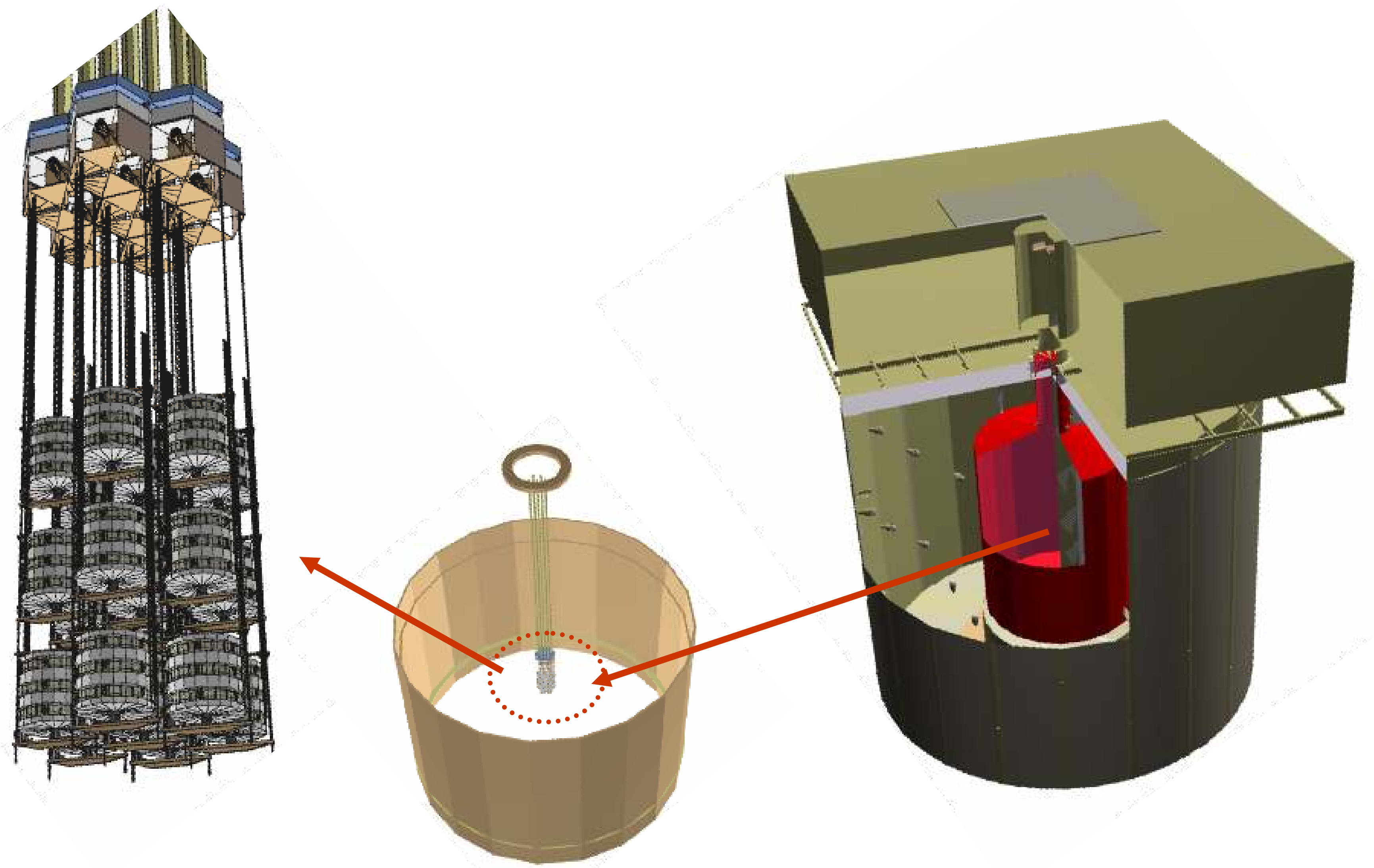
- **SLAC-SPIRES HEP** (refers to, cited by, arXiv reformatted)
- **CiteBase**

<< **nucl-ex** >>
new | recent | 0802

Monte Carlo Campaign II

- Gerda geometry updated
- Software updated
- New computation and storage system
- And more…

New Gerda geometry



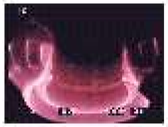
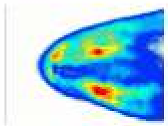
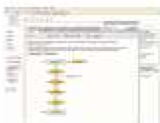
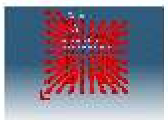
New version of software

Some bugs fixed
Geometry updated
Segmentation improved

```
MCC2 setup:

      CLHEP:   /afs/ipp/mpp/gerda/soft/clhep-2.0.3.2
      ROOT:    /afs/ipp/mpp/gerda/soft/root-5.18
      Geant4:  /afs/ipp/mpp/gerda/soft/geant4-9.1
      G4data:  /afs/ipp/mpp/gerda/soft/g4data/G4EMLOW5.1
               /afs/ipp/mpp/gerda/soft/g4data/G4NDL3.12
               /afs/ipp/mpp/gerda/soft/g4data/PhotonEvaporation2.0
               /afs/ipp/mpp/gerda/soft/g4data/RadioactiveDecay3.2
               /afs/ipp/mpp/gerda/soft/g4data/G4ABLA3.0
      MaGe:    /afs/ipp/mpp/gerda/soft/MaGe (Tag: MCC2-2007-12-20)
      MaGe executable:
               /afs/ipp/mpp/gerda/bin/mcc2
      MGGERDAGEOMETRY:
               /afs/ipp/mpp/gerda/soft/MaGe/gerdageometry
      G4WORKDIR:
               /afs/ipp/home/j/jingliu/work/geant4
```

Computation and storage

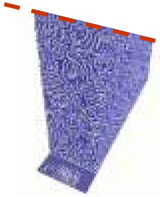
Rechenzentrum Garching
Max-Planck-Gesellschaft & IPP

RZG
Rechenzentrum - Garching

A member of

Distributed
European
Infrastructure for
Supercomputing
Applications



Linux Compute Clusters

3.2 GHz) and AMD Opteron processors (2.2 GHz to 2.8 GHz). Intel Xeon processors are operated in IBM-Blade Center technology, older systems with 32 bit Linux, the new Woodcrest systems with 64 bit Linux.
The AMD opteron systems are all operated with 64 bit Linux (x86_64), partly equipped with an Infiniband interconnect. In total, more than 2,500 processor cores are in operation. Currently, all systems are running Novell/SuSE SLES 9.

Share dcashe storage system with ATLAS.
5 Tb available currently

Simulation of tolerable contaminations

- ^{232}Th in water, cryostat
- ^{222}Rn inside cryostat
- Crosscheck from Russia
- ^{232}Th in cables and pogo pins

Maximum ^{232}Th activity

Calculations performed to evaluate the maximum ^{232}Th activity

in water, SS of cryostat and Cu inner shielding

using the method of GSTR-2006-007 and GSRT-2007-017

Maximum background of 10^{-4} cts/(keV kg y)	Maximum ^{232}Th activity without cuts (PhaseII*)	Maximum ^{232}Th activity with detector anticoincidence (PhaseII*)	Maximum ^{232}Th activity with segment anticoincidence (PhaseII*)
Water	42 mBq/kg	74 mBq/kg	105 mBq/kg
Stainless steel	26 mBq/kg	46 mBq/kg	64 mBq/kg
Copper	110 mBq/kg	190 mBq/kg	270 mBq/kg

*24 detectors: 15 segmented (probably non realistic) + 9 non segmented

Note:

- Purity of water: 1 mBq/kg in ^{232}Th (before Borexino plant)
  0.3 μBq/kg in ^{232}Th (after Borexino plant)
- Radiopurity of stainless steel less critical because LAr and Cu shielding

Maximum ^{222}Rn activity

Full simulation performed to evaluate the

maximum ^{222}Rn activity which is tolerable **inside the cryostat.**

Results reported in **GSTR-07-020**.

Maximum ^{222}Rn emanation rate in the cryostat

for **Background<10^{-4} cts/(keV kg y)**:

8 mBq for Phase II*, no cuts

14 mBq for Phase II*, segment anti-coincidence

*24 detectors: 15 segmented (probably non realistic) + 9 non segmented

- ^{214}Bi decays are produced **uniformly distributed** in the cryoliquid
- Old Gerda geometry is used

Crosscheck from Russia

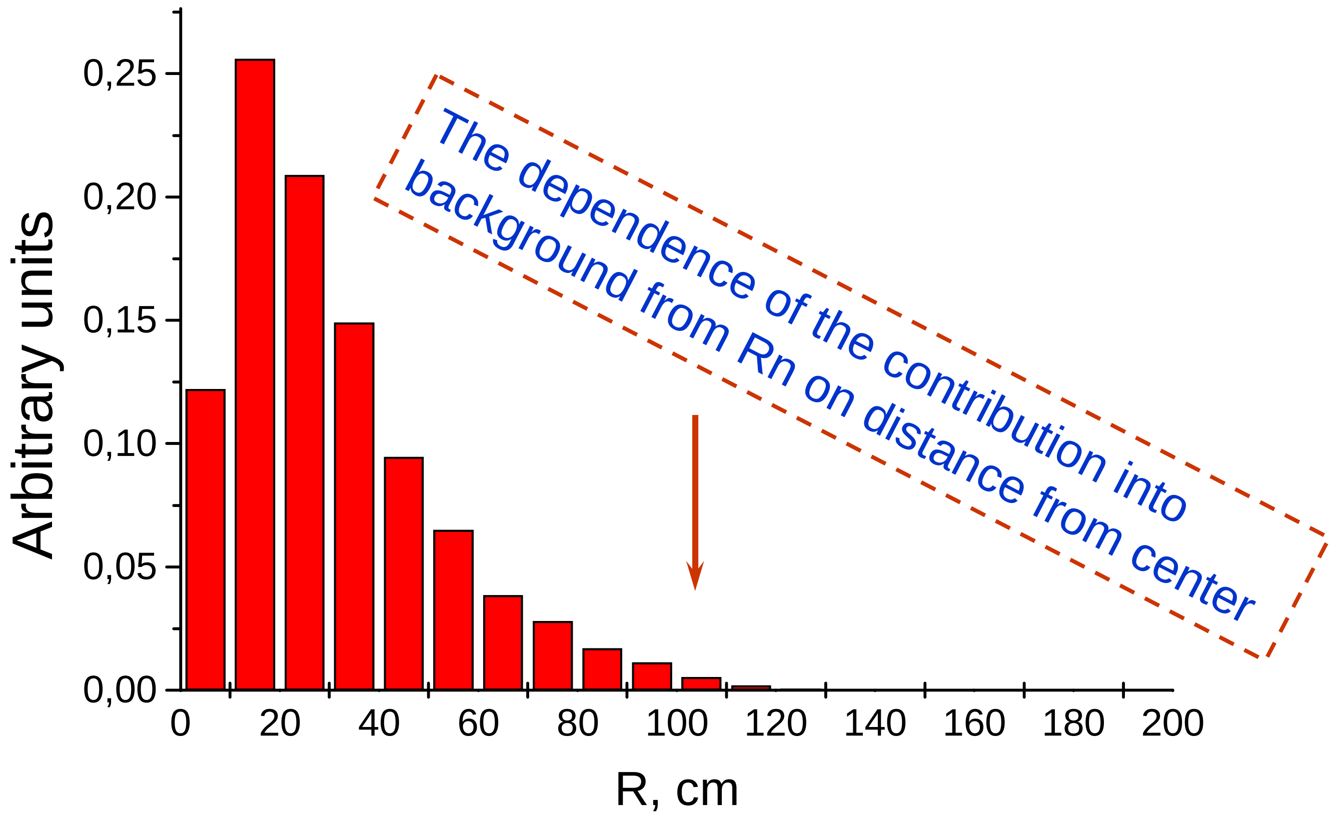
The background from Rn in liquid argon is calculated for one crystal with mass 2 kg. The result is:

at Rn activity of **1 μBq/kg the background index is 1.0×10^{-3} cts/(keV kg y)**

~80 tons of LAr

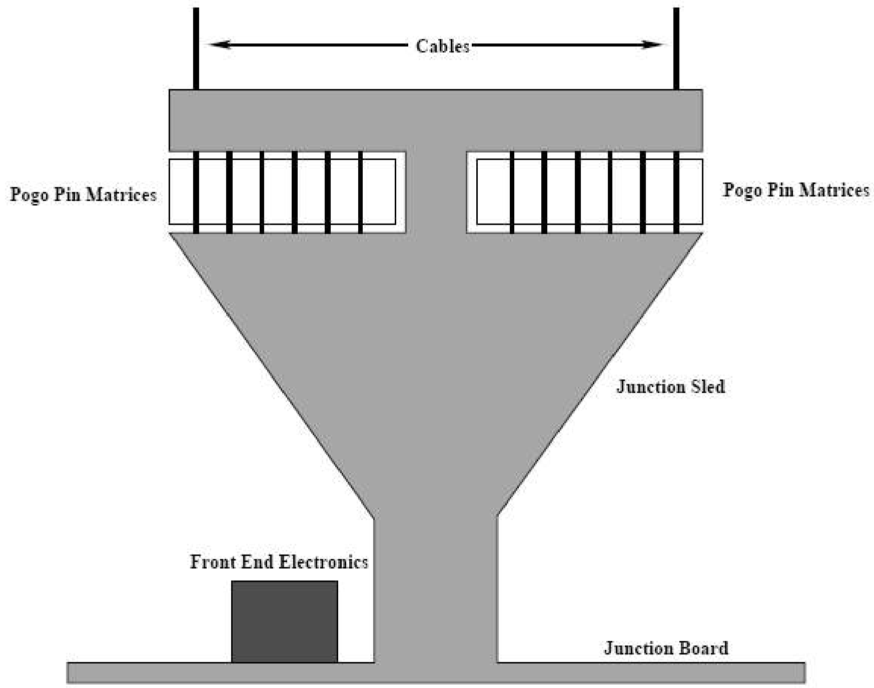
~8mBq without anti-coincidence

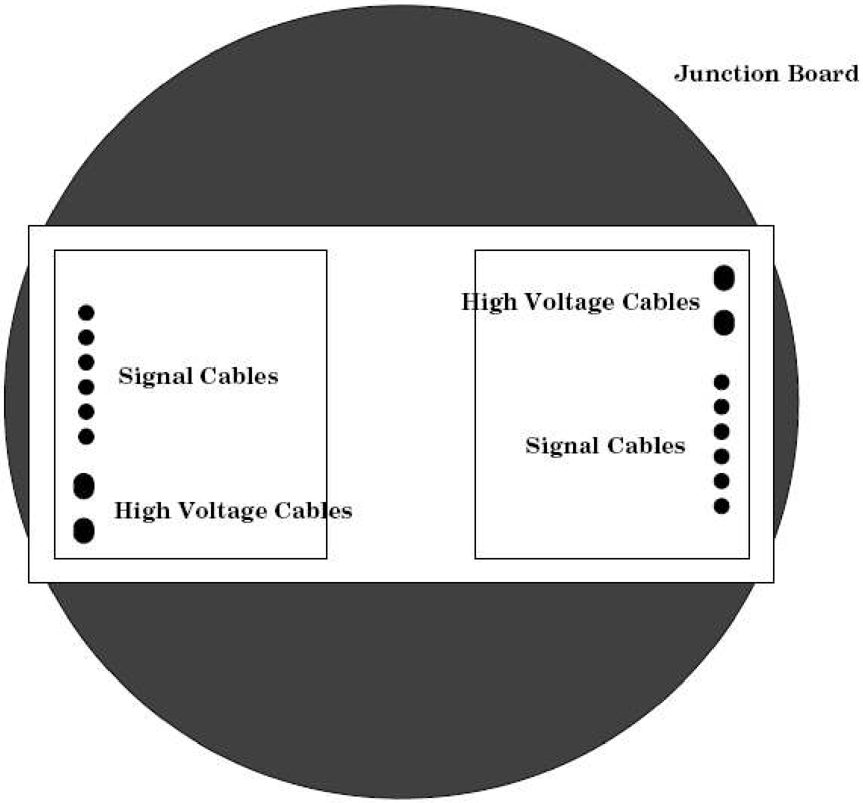
Consistent with MaGe!



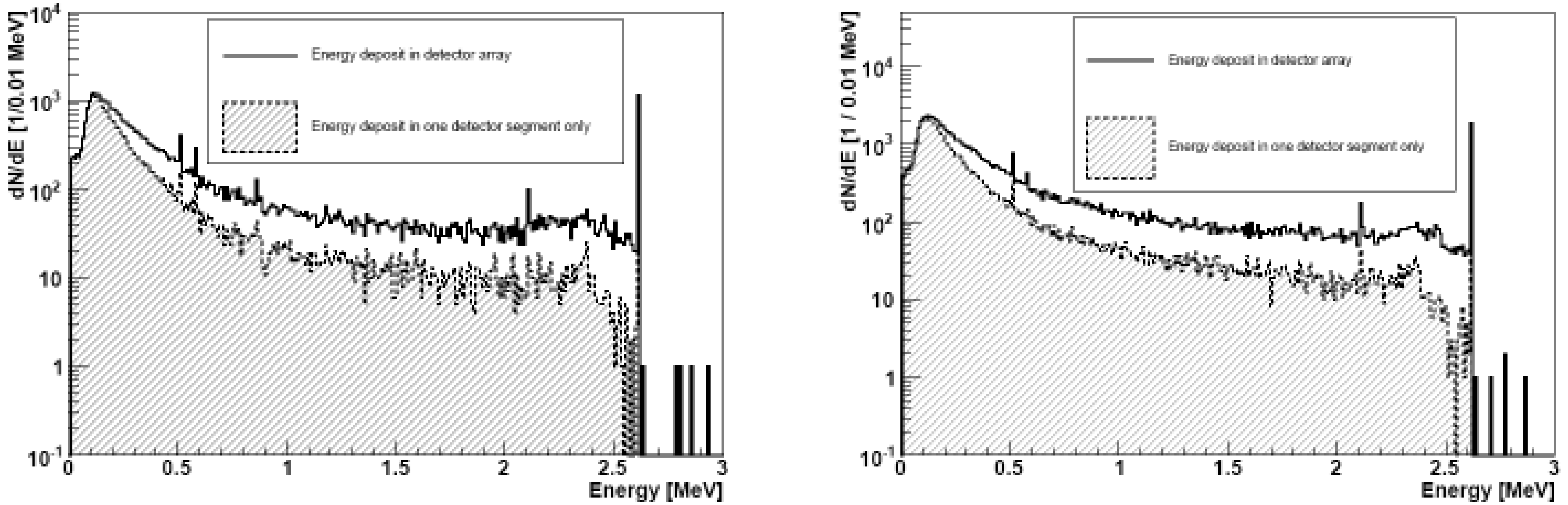
Contamination from cables and pogo pins

Each string has 120 pogo pins and 16 cables. The pins are divided into two 60 pin arrays



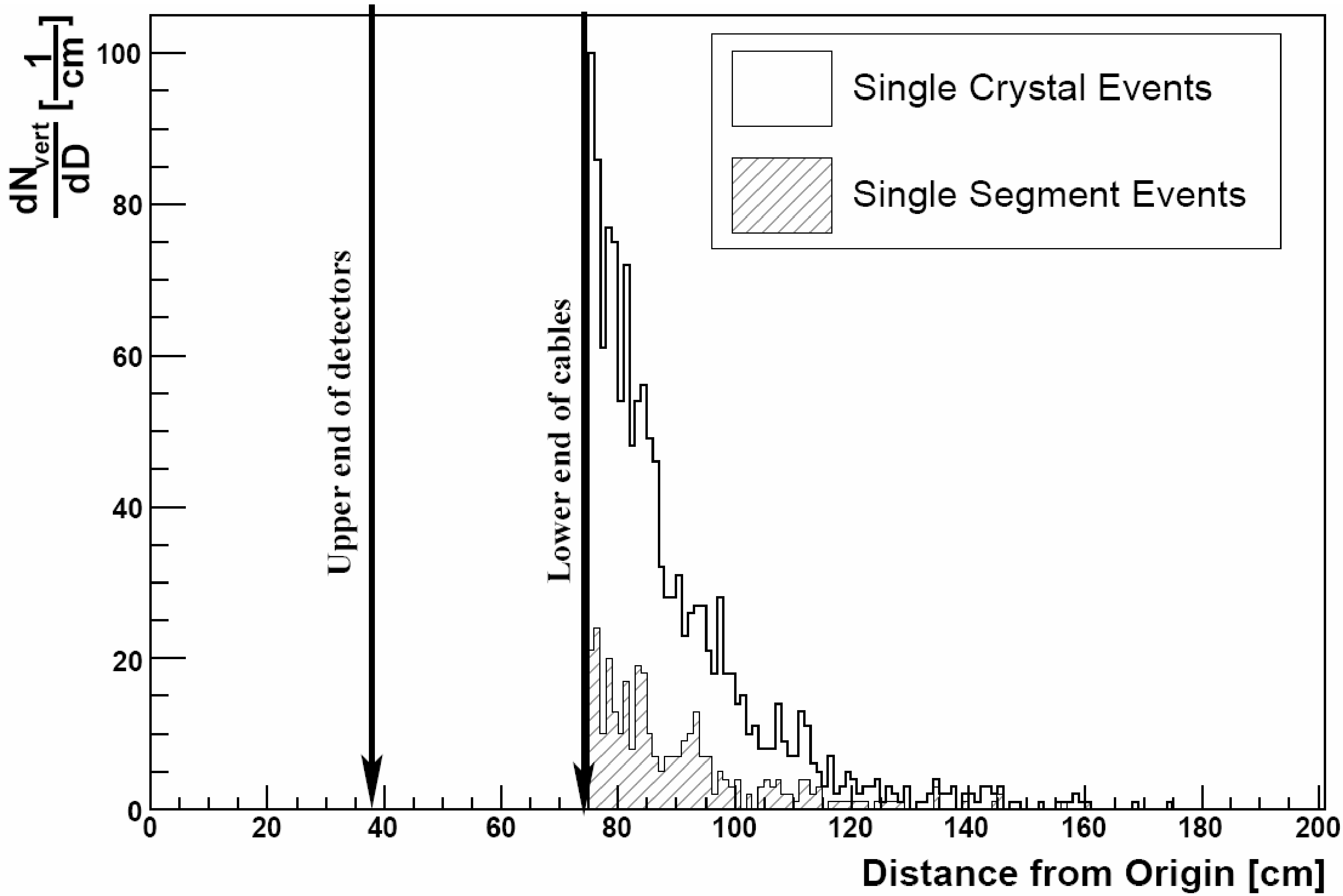


Energy spectra



Energy spectrum of ^{208}Tl decay in the pogo pins (left) and in the cables (right) as seen by the detectors (*open histogram*) and by single detector segments (*hatched histogram*). Energy depositions in the detectors of less than 0.01 MeV in one decay are disregarded.

Dangerous vertex distribution



Maximum radioactivity in cable

GERDA

GERDA Scientific / Technical Report GSTR-08-010

January 16th 2008

Estimate of Background Contributions from Cable Connectors and Cables

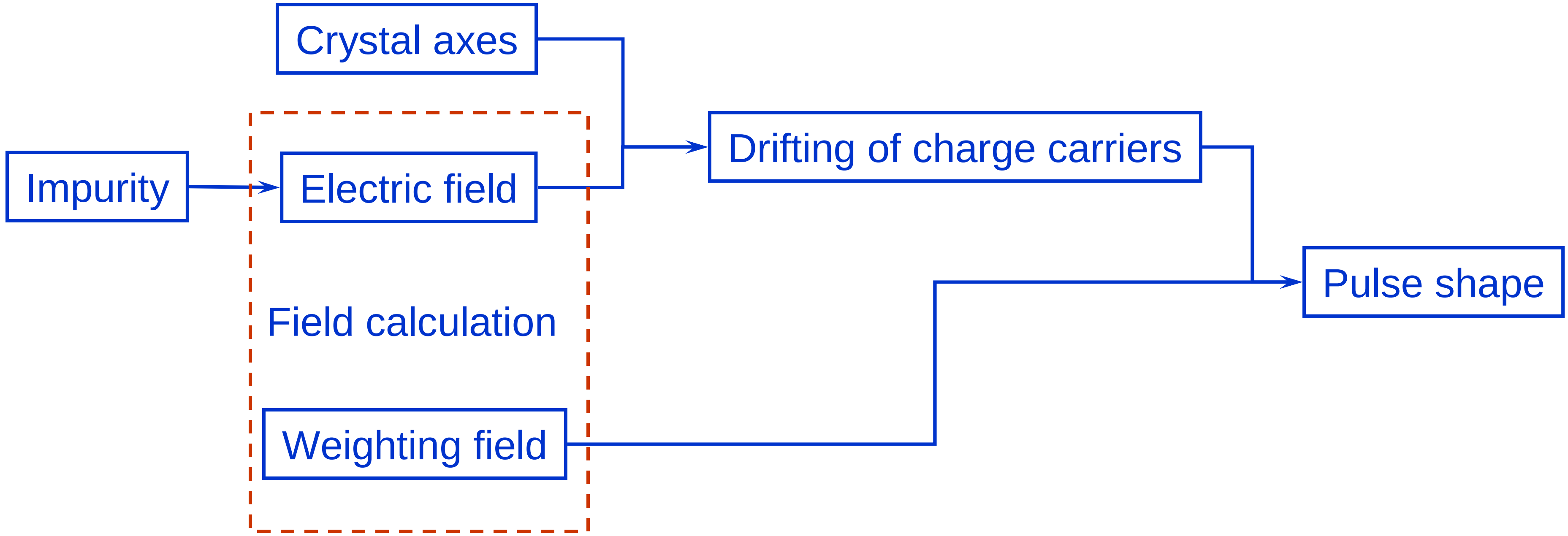
Daniel Lenz

The contamination resulting in a background index of 10^{-4}cts/(kg · keV · y) from ^{208}Tl decay in the cables is 2.91 ± 0.16 mBq/kg using the single segment requirement and 0.70 ± 0.02 mBq/kg using the single crystal requirement. This contamination is equivalent to one of ^{232}Th of 8.03 ± 0.44 mBq/kg and 1.93 ± 0.06 mBq/kg for single segment requirement and single crystal requirement, respectively. The absolute activity of the cable resulting in a background index of 10^{-4}cts/(kg · keV · y) is 3.64 ± 0.20 mBq and 0.88 ± 0.02 mBq for single segment and single crystal requirement, respectively.

Pulse shape simulation

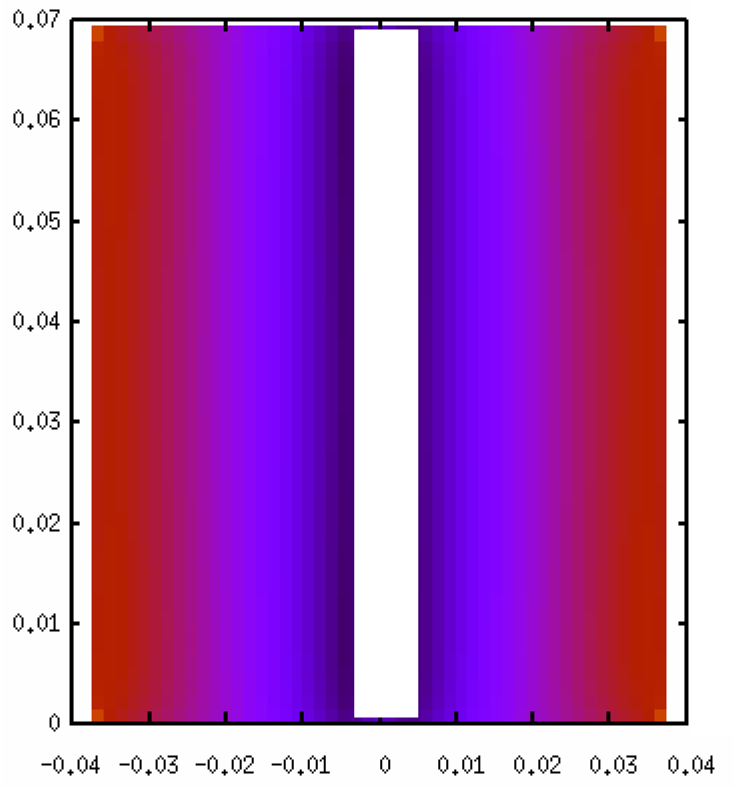
- Framework
- Field calculation

Flowchart of pulse shape simulation

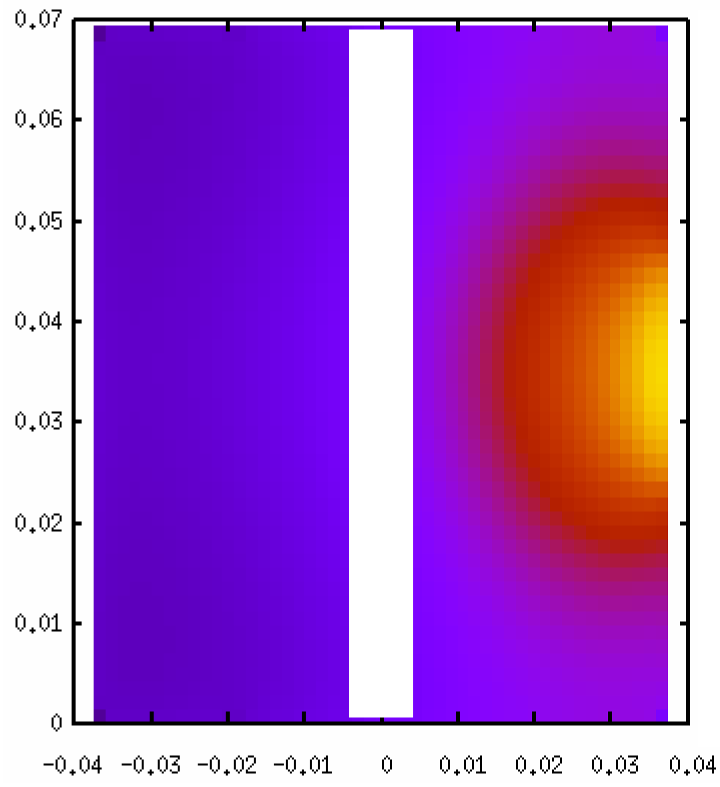


Field calculation

Electric Field



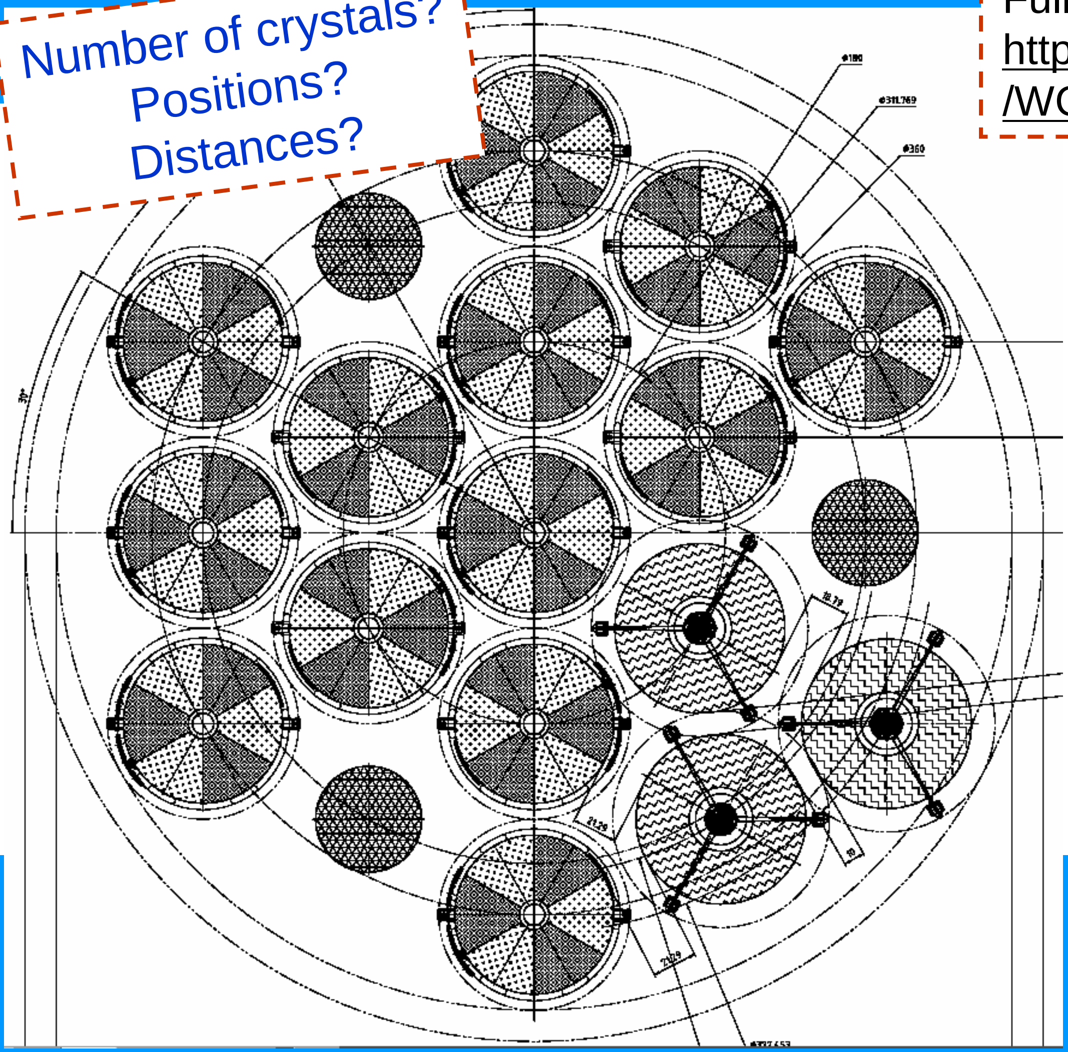
Weighting Potential



Summary

- New developments of MaGe going well
- MaGe paper submitted
- MC campaign II of Gerda well prepared; There have been lots of results of tolerable contaminations in crucial parts of GERDA. More coming up.
- Package for pulse shape simulation under development. More results to be reported in the next meeting

Number of crystals?
Positions?
Distances?



Full list:
http://wwwgerda.mppmu.mpg.de/~schubert/WORK/GERDA/MCC2/quick_notes.html

Positions of Crystals as in MC [2008-01-28]:

i_crystal	X	Y	Z
0	0	180	325
1	0	180	195
2	0	180	65
3	0	180	-65
4	0	180	-195
5	77.9423	135	325
6	77.9423	135	195
7	77.9423	135	65
8	77.9423	135	-65
9	77.9423	135	-195
10	155.885	90	325
11	155.885	90	195
12	155.885	90	65
13	155.885	90	-65
14	155.885	90	-195
15	155.885	0	325
16	155.885	0	195
17	155.885	0	65
18	155.885	0	-65
19	155.885	0	-195
20	155.885	-90	325
21	155.885	-90	195
22	155.885	-90	65
23	155.885	-90	-65